The present invention relates to a method of managing or controlling, especially remotely, an electric arc welding shop in which several welding torches are employed.

The productivity of a welding shop is a combination of several factors and may thus be expressed in several ways, especially in the form of a deposition rate, that is to say the amount of material deposited in one hour by a welder, said amount of material corresponding to the amount of consumable wire used to produce the welded joint.

Current, wire speed, welding speed or shop efficiency parameters are all related to the efficiency of the welding.

If we consider that the size of the weld beads produced meets the specifications, then by increasing the wire speed, and therefore the current for the process, the rate of displacement of the arc is increased, which therefore means a longer weld bead deposited per unit time.

Likewise, any increase in the level of utilization of the shop or in the effective time during which the arc is ignited will have a favorable impact on the deposition rate of the shop.

The efficiency of a welding shop may be improved provided that there are suitable diagnostic and monitoring tools for identifying the causes of inefficiencies, such as too low a wire speed, too low a current, too low a level of utilization of the welding machines, too short an effective arc ignition time, etc.

At the present time, lacking a suitable measurement or monitoring system, most manual welding professionals

use the total manufacturing time or the number of workpieces produced, over a given time period, as parameters for producing estimates, for defining the overall scheduling of the welding shop and above all to try to improve the productivity of their welding processes.

Unfortunately, using only such parameters it is not possible to take into account the actual utilization of the welding process, the efficiency of which depends not only on the duty factor of the process, namely the ratio of the time during which the electric welding arc is ignited to the total work time, but also on optimizing the welding parameters, when the arc is in operation, such as voltage, wire speed, current, type of gas mixture used and flow rate of the shielding gas used, angle of the torch with respect to the workpiece to be welded, direction of displacement, cleanliness of the workpieces, etc.

To improve the productivity of the shop, to produce accurate estimates and to manage the scheduling of the shop, it is therefore necessary to have accurate measurable values that are directly connected to the actual welding activity.

Although at the present time product shop management software products are commercially available, it turns out that these do not make it possible for measurable and reliable data that directly reflect the welding activity to be obtained automatically.

There are also what are called "multiparameter" measurement systems that extract measurable data associated with the process (current, voltage, wire speeds, etc.) and use them for traceability and quality assurance purposes, but not for strictly speaking managing and improving a welding shop in which several

torches are employed simultaneously by different operators.

In addition, these multiparameter systems necessarily employ several sensors for measuring the desired data, in particular the current, the voltage, the wire speed and the gas flow rate. However, it turns out that the cost of all these sensors and the system that uses them is usually high and therefore often dissuasive.

In short, all the systems that currently exist are too complex and/or their cost is several times greater than that acceptable from the industrial standpoint and/or give only mediocre or imperfect results.

At the present time, these is therefore no simple and economical system for the effective management of a welding shop in which several torches are employed simultaneously by different operators, that is to say one for making the link between a measured parameter and the management elements of the shop, namely the duty factor and/or the deposition rate.

The problem that the present invention aims to solve is therefore to optimize and/or improve the productivity of a welding shop in a simple, flexible and inexpensive manner, which can also be carried out remotely, that is to say via remote maintenance and/or remote management, in particular when several torches are employed simultaneously within this shop.

In other words, the object of the present invention is to propose a simple and inexpensive system using as few sensors as possible and allowing the productivity of the welding to be measured and, preferably simultaneously, optimizing the arc parameters, such as duty factor or deposition rate.

The solution of the invention method of managing or controlling an electric arc welding shop in which several welding torches, each fed to at least one consumable wire are employed each consumable wire (11) moving with a wire speed and being subjected to an electrical current of intensity, in which:

(a) for each torch, at least one wire speed value representative of the average speed at which each wire feeds each torch over a given period is determined by means of a speed sensor or at least one intensity value of the current representative of the average current to which each wire is subjected over the given period is determined by means of a current sensor; and

(b) at least one productivity parameter chosen from the duty factor DF and the deposition rate DR for each torch of the shop and/or optionally the average value of these parameters, for all the torches of the shop, is determined from at least each wire speed value or each intensity value of the electrical current obtained in step (a).

Depending on the case, the method of the invention may include one or more of the following technical features:

- the shop comprises 2 to 20 welding torches fed with one or more welding wires, preferably with one or two wires;
- it includes a step of storing at least one of said parameters and/or the wire speed or the current intensity;
- it includes a step of transmitting it to at least one of said parameters and/or the wire speed or said intensity to shop monitoring means, preferably a remote transmission step;
- it includes a step of acquiring and/or of storing at least one wire speed value determined by the speed sensor or at least one current intensity value determined by the current sensor;

- it includes a step of processing the wire speed values or the intensity values before and/or after storage, preferably before storage; and

- the step of processing each wire speed value or each intensity value consists in calculating at least one productivity parameter chosen from the duty factor and the deposition rate for each torch of the shop and/or optionally the average value of these parameters for all the torches of the shop.

The invention a system for managing or controlling an electric arc welding shop in which several welding torches each fed with at least one consumable wire are employed, each consumable wire moving with a wire speed and being subjected to an electrical current of intensity, comprising:

(a) first determination means, for each torch, comprising a speed sensor for determining at least one wire speed value representative of the average speed at which each wire feeds each torch over a given period or comprising at least one current sensor for determining at least one current intensity value representative of the average current to which each wire is subjected over the given period; and

(b) second determination means that cooperate with the first determination means in order to determine, from at least each speed value of the wire or each intensity value of the electrical current determined by the first determination means, at least one productivity parameter chosen from the duty factor and the deposition rate for each torch of the shop and/or optionally the average value of these parameters for all the torches of the shop.

Depending on the case, the system of the invention may include one or more of the following technical features:

- it includes storage means for storing at least one productivity parameter chosen from the duty factor

and the deposition rate and/or at least one wire speed value and/or current intensity for at least one torch of the shop;

- it includes transmission means for transmitting at least one of said productivity parameters and/or the wire speed or said current to shop monitoring means; and

- it comprises acquisition and/or storage means for acquiring and/or storing at least one wire speed value determined by the speed sensor or at least one current intensity value determined by the current sensor; and/or processing means for processing the wire speed values and/or the intensity values before and/or after storage.

During a welding operation three vectors coexist, namely the arc, which is the welding energy vector, the consumable welding wire, which is the material vector (filler metal), and the gas, which is the atmosphere (gas shielding) vector.

Consequently, the time during which an arc is ignited or the duty factor may be measured in three different ways, namely:

- either by the electrical measurement of the time during which the current or the voltage are nonzero, which corresponds to the time during which the arc exists;

- or by measuring the time during which the flow rate of the gas is nonzero, which corresponds to the time when the gas is present;

- or by measuring the time during which the wire unreeling speed is nonzero, which corresponds to the time during which material is supplied.

According to a first aspect of the invention, specifically choosing the measurement of the wire unreeling speed, also called the "wire speed" or more simply "wire feed speed", makes it possible both:

- to measure the time during which the wire is being unreeled and melted by the arc, which therefore also corresponds to the time during which the arc is ignited, as otherwise the wire would not be melted and would not be unreeled, and therefore the wire feed speed would always be zero; and

- to simultaneously measure the amount of material supplied and melted, which represents, to within a few % by weight, the amount of metal deposited by the welder, also called the "deposition rate"; the deposition rate is the ignited arc productivity parameter.

Using the wire speed measurement therefore results in a measure of the optimization of the arc when it is ignited.

According to one aspect of the invention, a single current sensor is used to determine the intensity of the electrical current.

It is because it is well known that, for each type of wire, there exists an operating range that links the current intensity value (also called the "value of the current") and the wire speed value.

Consequently, measuring the wire speed or the current value leads to a very similar result once the relationship in question has been stored, it being possible to store this within a suitable program (software).

For further details, reference may be made to the document: *"Les procédés de soudage à l'arc, Les Soudages TIG, MIG et MAG"* [Arc welding processes: TIG, MIG and MAG welding], Air Liquide, published in May 1995, which explains the relationship between wire speed and current intensity depending on the nature of

the welding wire in question and of the gas used; see in particular pages 26, 35 and 44.

The basic idea of the present invention is therefore to measure, with a single wire speed or current sensor, the productivity of the arc welding, such as MIG/MAG, through the duty factor and the deposition rate.

The wire speed or the current may be measured very easily by means of a single, commercially available, sensor located at the point of exit of the wire from the feeder in the case of the wire speed sensor or on the secondary of the generator in the case of the current sensor, respectively.

From this, knowing the amount of metal to be deposited for a given joint length to be produced, it is easy to relate this value to the measurements made of the deposition rate in order to provide an overall manufacturing time for the workpiece to be welded.

By taking these two values into consideration, namely the amount of metal to be deposited and the deposition rate, it is then possible to provide welding sets that can carry out the manufacture and their load factors, that is to say the scheduling within the welding shop, and produce realistic estimates from the manufacturing times defined.

The present invention therefore makes it possible, using a single simple wire speed or current sensor, together with a welding productivity measurement, to produce a tool for making manufacturing estimates and to produce a welding shop scheduling tool.

A fuller understanding of the invention will be gained from the description that follows of an example of the implementation of the invention, illustrated in figure

1 appended hereto, in which a wire speed sensor is used.

Figure 1 shows a manual welding shop using N welding sets denoted 1 to N. A typical value of N is, for example, between 6 and 12, but could in certain circumstances exceed one hundred, or alternatively could be less than 6.

Each welding set 1, 2, ... N, also called a generator, comprises a welding torch 10 fed with welding wire 11 by a wire feeder or any other wire feed means, incorporated here within each generator.

The welding current is generated and then delivered to each torch 10 by the welding generators 1, 2, ... N which here are conventional units, such as MIG/MAG generators sold by Soudure Autogène Française.

The torches 10 are also fed with welding gas via gas lines carrying pure gases or mixtures of several gaseous compounds, for example gases or gas mixtures of the ARCAL™ range sold by Air Liquide.

One of the ends of the (or each) consumable wire 11 is progressively melted in the electric arc so as to deposit molten metal along the entire welded joint in the process of being produced, which molten metal solidifies, after deposition, as a welded joint at the junction between the workpieces to be joined.

A wire speed sensor 12 is placed in the path of each welding wire 11, inside or outside each generator 1 to N. Preferably, the same sensor 12 is mounted on all the sets 1 to N, independently of the type of generator, thereby making it possible to monitor the speed of the wire 11 for all the sets 1 to N of the shop.

According to one way of implementing the invention, a data processing and storage facility (not shown), for example comprising a processor, one or more RAM memories, a software product installed on an EPROM, an analog/digital converter card and a communication protocol, is provided within the sensor 12, thereby making it possible to limit the datastream to the acquisition means 20 to only useful digital values or, depending on the case, to the values averaged over a given time period. Of course, the data sampling frequency and the period over which the averaging is carried out can be parameterized.

The speed sensors 12 are connected 14, directly or indirectly, to analog or digital communication ports 20 or acquisition paths, for example via wires.

The acquisition means 20 make it possible to acquire, store and/or process all or some of the information that is sent to them by the sensors 12 or the processing/storage facilities associated with said sensors 12.

Next, the data acquired by the acquisition means 20 is then sent to and stored in a data processing unit 15, such as a central computing unit of the PC type, located for example in or near the shop.

This data processing unit 15 calculates, in real time, the duty factor DF, which is defined as the percentage time during which the arc is ignited, and the deposition rate DR, which is defined as the amount of material deposited per unit time for each of the various sets 1 to N.

The values thus obtained make it possible to follow, over the course of time, the workload of each set 1 to N and the standard deviation of the measured values,

making it possible to determine the regularity of each set 1 to N.

For each type of work carried out on each set 1 to N, it is then relatively easy to define typical manufacturing profiles for the broad categories of workpieces, from knowledge of the duty factor and the deposition rate for each of the broad categories of workpieces depending on the generator used. These typical profiles, organized in the form of a library of models and constantly updated, will also be able to be used to produce future estimates.

Upon receiving any new command, the person responsible for scheduling the shop chooses a type of manufacturing model and assigns it to a work set, depending on the planned workload. In this way, the planned management of the workload of each machine in the shop may be accomplished.

Moreover, so as to allow the various sets 1 to N to be monitored or managed remotely, the data acquired by the acquisition means 20 and/or stored in the data processing unit 15 may be remotely transmitted, for example, by a communication network 16, such as the Internet network, to a central remote control device 17 where this data can be saved, analyzed, processed, etc. in order to extract, for example, trends therefrom so as to be able, for example, to activate alarms or carry out a feedback operation on the welding sets for example.

The present invention has been employed in a shop for manufacturing metal cans, within which twelve welding torches can be used simultaneously to weld the metal cans. The twelve welding torches of the shop manufactured the same type of weld bead on the same type of workpiece.

The torches used in this shop worked according to a GMAW process, the wire was LAS-6 and the shielding gas was a mixture formed from 75% Ar and 25% CO_2.

The average wire speed, current and welding speed values were measured on the twelve torches of the shop before and, for comparison, after implementation of the invention: the results obtained are given in Tables I and II below, respectively.

The productivity of the shop was calculated in the form of a welding speed which, for the same joint, is proportional to the deposition rate (DR).

Table I: Before implementation of the invention

Work set No.	Wire speed (cm/min)	Average current (A)	Welding speed (cm/min)
1	584	95	41
2	709	152	49
3	800	135	59
4	635	95	59
5	599	173	41
6	853	143	52
7	663	134	55
8	660	135	49
9	536	127	51
10	813	154	47
11	584	150	47
12	483	125	31
Shop average	660	135	48

Table II: After implementation of the method of the invention

Work set No.	Wire speed (cm/min)	Average current (A)	Welding speed (cm/min)
1	940	182	66
2	958	155	51
3	889	165	59
4	1118	200	72
5	889	165	60
6	871	162	73
7	953	175	55
8	838	157	73
9	907	160	74
10	826	165	74
11	927	180	94
12	986	170	68
Shop average	925	170	68

Tables I and II clearly show that the method of the invention has made it possible to reduce the dispersion in the adjustment used by welders, to increase the wire speed by 40% and to increase the welding efficiency by more than 41% (expressed as the length of bead deposited per unit time).

The present invention therefore results in an appreciable improvement in the productivity of the shop thanks to better management of the torches.